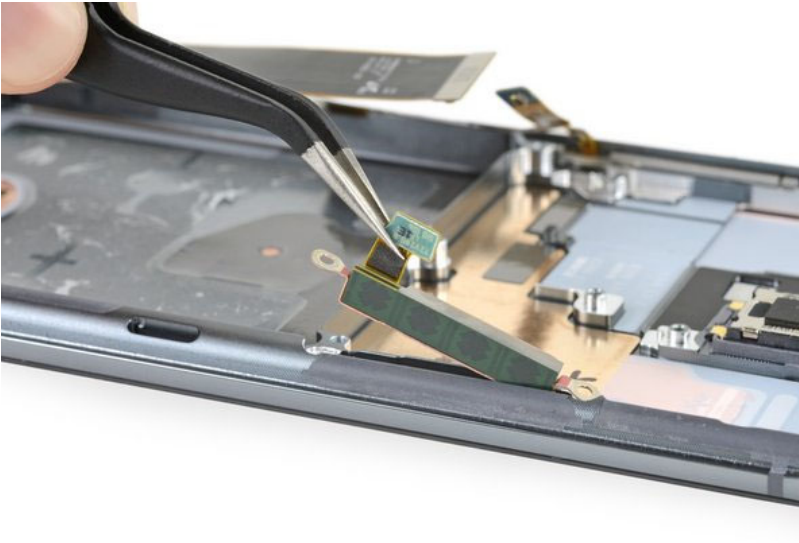


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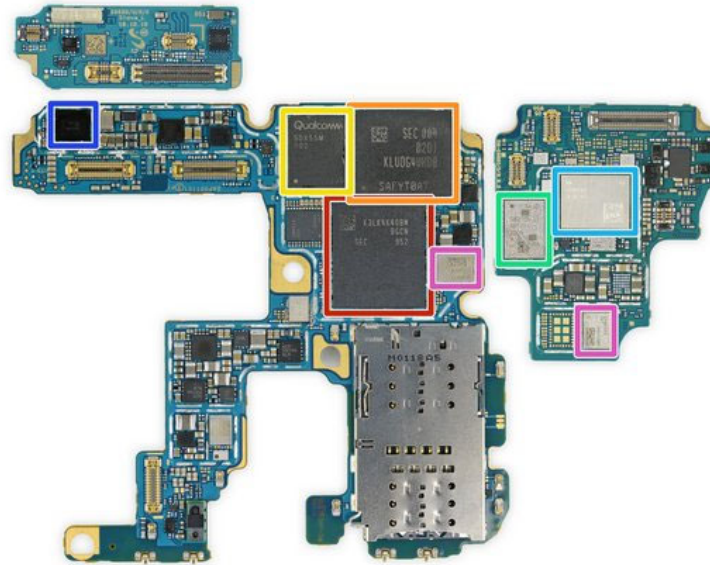
Claim 1	Accused Advanced Antenna Mobile Devices ¹
[1Pre] A wireless device, comprising:	The Accused Advanced Antenna Mobile Devices, such as smartphones and tablets (including but not limited to Galaxy S21-S25 model, the Galaxy Z Flip 3-6 model, the Galaxy Fold 3-6 model, and the Galaxy Note 20 model smartphones) are wireless devices.
[1A] one or more antennas wherein at least one of said one or more antennas includes one or more elements or sub-elements, said one or more antennas forming an antenna array; and	<p>The Accused Advanced Antenna Mobile Devices include one or more antennas for each of its wireless communication modalities, including but not limited to one or more antennas for cellular communication and Wi-Fi communication.</p> <p>Below is an image from a teardown of a Galaxy S20 Ultra model smartphone showing a mmWave antenna. See www.ifixit.com/Teardown/Samsung+Galaxy+S20+Ultra+Teardown/131607</p> 

¹ Upon information and belief, all Accused Advanced Antenna Mobile Devices function in a substantially similar manner for the relevant accused functionality.

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	<p>The Qualcomm Snapdragon 5G solutions include phased-array antennas. See https://www.qualcomm.com/developer/blog/2021/05/riding-wave-5g-millimeter-time (“Our first 5G product, the Snapdragon® X50 5G Modem-RF System introduced in 2016, is backed by the Qualcomm® QTM052 mmWave antenna module. The system also combines 5G transceivers, power management, and RF front-end components, including power amplification and a phased-antenna array to focus mmWave signals for beamforming.”)</p>
<p>[1B] a plurality of transmitters, receivers or transceivers that operate in one or more frequency bands,</p>	<p>The different wireless communication modalities in the Accused Advanced Antenna Mobile Devices operate on different frequency bands. Wi-Fi and 5G also have multiple frequency bands. The Accused Advanced Antenna Mobile Devices comprise a plurality of transmitters, receivers or transceivers that operate in the various frequency bands.</p> <p>The Qualcomm Snapdragon 5G solutions include transceivers. See https://www.qualcomm.com/developer/blog/2021/05/riding-wave-5g-millimeter-time (“Our first 5G product, the Snapdragon® X50 5G Modem-RF System introduced in 2016, is backed by the Qualcomm® QTM052 mmWave antenna module. The system also combines 5G transceivers, power management, and RF front-end components, including power amplification and a phased-antenna array to focus mmWave signals for beamforming.”)</p>
<p>[1C] wherein at least one antenna of said antenna array is used by said plurality of transmitters, receivers or transceivers in a plurality of different bands,</p>	<p>The Accused Advanced Antenna Mobile Devices are operable for 5G cellular networks and 5G has multiple frequency bands, including sub-6 MHz bands and mmWave bands. The Accused Advanced Antenna Mobile Devices comprise at least one antenna used by two or more of the transmitters, receivers or transceivers of the different frequency bands.</p> <p>For example, the below image from a Galaxy S20 Ultra teardown shows a Qualcomm SDX55M 5G modem in the yellow rectangle. See www.ifixit.com/Teardown/Samsung+Galaxy+S20+Ultra+Teardown/131607</p>

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The SDX55M 5G modem is for one or more antennas that operate a different 5G bands. See below diagram of SDX55 5G Modem-RF System from www.qualcomm.com/products/technology/modems/snapdragon-x55-5g-modem. See also www.qualcomm.com/content/dam/qcomm-martech/dm-assets/documents/x55_9_final.pdf

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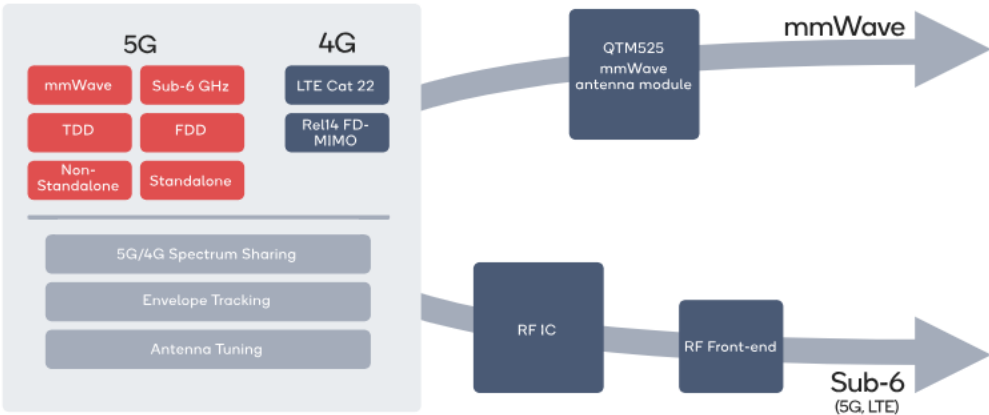
	<p style="text-align: center;">5G NR Multi-Mode Modem-to-Antenna Solution</p> 
<p>[1D] wherein said at least one antenna is one or more of a) an actively tuned antenna, and b) is tuned by one or more passive elements which are selected or interconnected using electronic control.</p>	<p>The antenna used by a plurality of transmitters, receivers or transceivers in multiple frequency bands in the Accused Advanced Antenna Mobile Devices is tuned to operate at a selected frequency band. This is explained, for example, in “Criticality of 5G Modem to RF Integration; A look inside Samsung Galaxy S20 Ultra,” April 2020 (omdia.tech.informa.com/om006104/criticality-of-5g-modem-to-rf-integration-a-look-inside-samsung-galaxy-s20-ultra, hereinafter “Omdia”), which explains that with all of the higher 5G frequencies, the solution is “antenna tuners.”</p> <div style="border: 1px solid black; padding: 10px; margin-top: 10px;"> <p>With all these different higher 5G frequencies requiring 4x4 MIMO, antenna design becomes much more daunting in modern 5G devices. A typical LTE device may have upwards of 6 cellular antennas. Some high-end devices exhibit more due to the higher number of frequencies supported. However, the volume inside a device like the smartphone is still finite and designers can only fit in so many physically tuned antennas. The solution for that are antenna tuners. Antenna tuners are vital to 5G as higher frequencies and 4x4 MIMO requirements drive up need for more antennas. In the case of the Galaxy S20 Ultra design, Samsung is using up to five Qualcomm antenna tuners in the design.</p> </div>

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The Qualcomm Snapdragon (SN) modems, which are in at least some of the Accused Advanced Antenna Mobile Devices, include “antenna modules” with “adaptive antenna tuning.” See <https://www.qualcomm.com/products/technology/modems/rf>.

Antenna tuning solutions

Our comprehensive multi-tier portfolio of antenna performance enhancement technologies includes Qualcomm® AI-Enhanced Signal Boost, the world’s first AI antenna tuning technology that intelligently detects hand grips around the phone and keeps 5G multimode devices fine-tuned for fewer dropped calls, better coverage, and longer battery life.

Advanced tunability allows OEMs to design sleek smartphones and tablets with high signal performance, wide frequency range, and extensive band support.

See also Snapdragon X55 and 5G RF datasheet.
device.report/m/1cde5ac9c829a48d5afe8d9aadb0d0c993271ff7e3247850068f17979106bfad

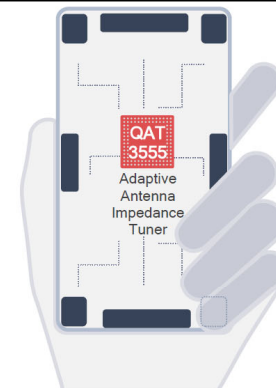
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World's First Announced

**5G NR
Adaptive Antenna Tuning
solution**

Qualcomm® QAT3555

- Better indoor coverage¹
- Longer battery life¹
- Faster, more consistent data speeds¹
- Fast time-to-certification and launch for OEMs



Qualcomm® Signal Boost 5G
adaptive antenna tuning solution

Support for growing antenna count in 5G
600 MHz - 6 GHz antenna frequency support
25% reduced package height for sleek devices²

www.slideshare.net/slideshow/powerpointpresentationmaking5gnrrealityfebruary2020webpdf/252983614

See also “Qualcomm Announces Second Generation 5G RF Front-End Solutions for Sleeker, More Efficient 5G Multimode Mobile Devices,” Feb. 2019

(www.qualcomm.com/news/releases/2019/02/qualcomm-announces-second-generation-5g-rf-front-end-solutions-sleeker-more), which describes that its Snapdragon 5G modems include an “adaptive antenna tuner” for “extending adaptive tuning technology to 5G bands up to 6 GHz ...”

To help OEMs address the growing number of antennas and frequency range support required in mobile devices, Qualcomm Technologies has also introduced the QAT3555 Signal Boost adaptive antenna tuner, extending adaptive antenna tuning technology to 5G bands up to 6 GHz, while featuring a 25% reduced package height, and lower loss compared to the previous generation.

A Qorvo White Paper, “Aperture Tuning: An Essential Technology in 5G Smartphones”

(www.qorvo.com/resources/d/qorvo-antenna-tuning-essential-technology-5g-smartphones-white-paper) explains that to accommodate the multiple antennas needed for 5G, but in small phone form factor, “[a]perture tuning compensates for this problem by allowing antennas to be tuned to operate efficiently on

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multiple bands ...” and that “[a]perture tuning also lets antennas communicate on multiple bands simultaneously to support” carrier aggregation.

Antenna aperture tuning is essential to enable smartphones to operate efficiently over the ever-increasing range of RF frequency bands and support the transition to 5G. Smartphones need more antennas to support growing RF requirements such as new 5G bands, MIMO, and carrier aggregation (CA), but there is less space for these antennas due to changes in smartphone industrial design. As a result, antennas are becoming smaller, potentially reducing antenna efficiency and bandwidth. Aperture tuning compensates for this problem by allowing antennas to be tuned to operate efficiently on multiple bands and increasing Tx and Rx performance by 3 dB or more. Aperture tuning is implemented with switches combined with other tuning components; switches with low RON and low COFF are critical to maximize efficiency. Aperture tuning also lets antennas communicate on multiple bands simultaneously to support CA. Implementing aperture tuning requires in-depth knowledge of how to apply the technology for each application.

This paper explains that aperture tuning utilizes a switch along with a capacitor and/or inductor as tuning components. This is an example of “active” tuning. (i.e., part (a) of this claim element).

Samsung uses Qorvo’s RF solutions for its Galaxy platform. See www.qorvo.com/newsroom/news/2021/qorvo-recognized-by-samsung-for-best-quality-in-mobile; www.techinsights.com/blog/deep-dive-teardown-samsung-galaxy-s24-sm-s921bds-smartphone.

Below is an image from teardown of a Galaxy S20 Ultra showing 4 antenna tuners. See Omdia.

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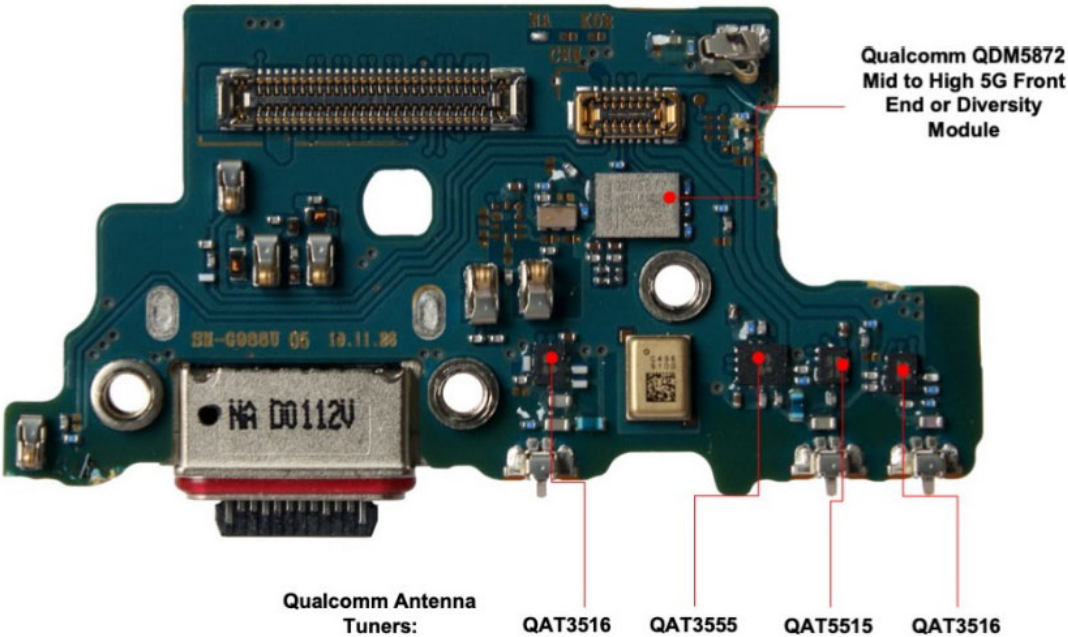
	
<p>Claim 3</p>	<p>Accused Advanced Antenna Mobile Devices</p>
<p>[3] The wireless device of claim 1 wherein said at least one antenna is used for transmitting, receiving, or transmitting and receiving simultaneously in said</p>	<p>The antennas and 5G modems used by a plurality of transmitters, receivers or transceivers in the Accused Advanced Antenna Mobile Devices are configure for simultaneous reception and transmission in different frequency bands.</p> <p>For example, the Accused Advanced Antenna Mobile Devices comprise Qualcomm Snapdragon 5G solutions include transceivers. See https://www.qualcomm.com/developer/blog/2021/05/riding-wave-5g-millimeter-time (“Our first 5G product, the Snapdragon® X50 5G Modem-RF System introduced in 2016, is backed by the Qualcomm® QTM052 mmWave antenna module. The system also combines 5G transceivers, power management, and RF front-end components, including power amplification and a phased-antenna array to focus mmWave signals for beamforming.”)</p>

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plurality of different bands.	<p>The 5G modem supports active tuning with the antenna to permit the reception and transmission of wireless communication on two different bands simultaneously. See www.qorvo.com/design-hub/blog/4-things-to-know-about-antenna-tuning-in-4g-5g-smartphones</p> <div style="border: 1px solid black; padding: 5px; margin: 10px 0;"> <p>CA combines two or more LTE carriers, often in different frequency bands, to deliver increased bandwidth and higher data rates. Due to the limited total number of antennas in handsets, this often means that a single antenna must communicate on two bands simultaneously.</p> </div> <p>See also www.qorvo.com/resources/d/qorvo-antenna-tuning-essential-technology-5g-smartphones-white-paper, which explains that to accommodate the multiple antennas needed for 5G, but in a small phone form factor, “[a]perture tuning compensates for this problem by allowing antennas to be tuned to operate efficiently on multiple bands ...” and that “[a]perture tuning also lets antennas communicate on multiple bands simultaneously to support” carrier aggregation.</p>
Claim 8	Accused Advanced Antenna Mobile Devices
[8Pre] A wireless device, comprising:	See element [1Pre] above.
[8A] one or more antennas wherein at least one of said one or more antennas includes one or more elements or sub-elements, said one or more antennas forming an antenna array; and	See element [1A] above.
[8B] at least one multiband transmitter, receiver or transceiver;	See element [1B] above.
[8C] a tuner associated with said at least one multiband transmitter,	As describe above for element [1D], the Accused Advanced Antenna Mobile Devices include a tuner for actively tuning the antenna.

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receiver, or transceiver; and	
[8D] a controller for controlling tuning of the tuner to a plurality of different bands,	The controller in the Accused Advanced Antenna Mobile Devices is the component that controls the tuning by the antenna tuners.
[8E] wherein at least one antenna of said antennas antenna array is used by said at least one multiband transmitter, receiver or transceiver in a plurality of different bands,	The tunable antenna in the Accused Advanced Antenna Mobile Devices is used by the at least one multiband transmitter, receiver or transceiver in a plurality of different bands, such as a plurality of different 5G bands.
[8F] wherein said at least one antenna is one or more of a) an actively tuned antenna, and b) is tuned by one or more passive elements which are selected or interconnected using electronic control.	See element [1D] above.
Claim 9	Accused Advanced Antenna Mobile Devices
[9] The wireless device of claim 8 said at least one antenna is	See claim [3] above.

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used for transmitting, receiving, or transmitting and receiving simultaneously in said plurality of different bands.	
Claim 14	Accused Advanced Antenna Mobile Devices
[14Pre] A wireless device, comprising:	See element [1Pre] above.
[14A] at least one multiband antenna which includes one or more elements or sub-elements and which is configured to form an antenna array;	See elements [1A] and [1C] above.
[14B] at least one multiband transmitter, receiver or transceiver; and	See element [1B] above.
[14C] a tuner associated with said at least one multiband transmitter, receiver, or transceiver, said tuner matching said at least one multiband antenna to said at least	<p>See element [1D] above.</p> <p>Also, antenna tuning permits communicating on two bands simultaneously. See www.qorvo.com/design-hub/blog/4-things-to-know-about-antenna-tuning-in-4g-5g-smartphones</p> <div style="border: 1px solid black; padding: 5px; margin: 5px 0;"> <p>CA combines two or more LTE carriers, often in different frequency bands, to deliver increased bandwidth and higher data rates. Due to the limited total number of antennas in handsets, this often means that a single antenna must communicate on two bands simultaneously.</p> </div> <p>See also www.qorvo.com/resources/d/qorvo-antenna-tuning-essential-technology-5g-smartphones-white-</p>

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one multiband transmitter, receiver or transceiver in a plurality of different bands simultaneously.	paper, which explains that to accommodate the multiple antennas needed for 5G, but in a small phone form factor, “[a]perture tuning compensates for this problem by allowing antennas to be tuned to operate efficiently on multiple bands ...” and that “[a]perture tuning also lets antennas communicate on multiple bands simultaneously to support” carrier aggregation.
Claim 19	Accused Advanced Antenna Mobile Devices
[19Pre] A wireless portable device, comprising:	See element [1Pre] above. The Accused Advanced Antenna Mobile Devices are portable at least because they are handheld, wireless devices.
[19A] one or more antennas wherein at least one of said one or more antennas includes one or more elements or sub-elements, said one or more antennas forming an antenna array, said one or more antennas radiating or receiving electromagnetic energy at particular frequency bands, at least one of said one or more antennas radiating or receiving electromagnetic energy at a plurality of particular frequency bands;	See elements [1A] and [1C] above.

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<p>[19B] one or more components selected from the group consisting of receivers, transmitters and transceivers, said one or more components connected to said at least one of said one or more antennas, whereby</p>	<p>See element [1B] above.</p>
<p>[19C] at least one of said one or more components transmits or receives electromagnetic energy simultaneously at two or more of said plurality of particular frequency bands, or two or more components transmit or receive electromagnetic energy simultaneously at two or more of said plurality of particular frequency bands.</p>	<p>See elements [1D] and [14C] above.</p>